BACK TO MARS

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Two decades after humanity's last exploration of the red planet, a new international program of Mars study will begin late this year when NASA's and Caltech's Jet Propulsion Laboratory launches its Mars Global Surveyor orbiting mission and its Mars Pathfinder lander and micro-rover. Spacecraft from Earth last visited Mars in 1976 when two Viking orbiters and two landers conducted a very successful survey of the entire planet from orbit and detailed studies of the surface at the two landing sites. Both the United States and Russia have attempted Mars missions since Viking, but all have been unsuccessful. The most recent attempt was the U.S. Mars Observer mission which went silent just as it was being prepared for entry into Mars orbit in August 1993.

The new international program is designed to send a variety of smaller orbiters, landers, rovers, and balloons to Mars at every opportunity between now and 2005. With costs for space exploration increasing, and with most space-faring nations facing severe limits on their science budgets, ten space agencies have recently formed the international Mars Exploration Working Group (IMEWG) to conduct a comprehensive study of Mars over the next decade in a cooperative manner. No one nation will need to fund the entire effort, but all will be able to share in the much larger volume of science data. For its part, because of the need to reduce the federal deficit by cutting government costs, NASA has determined that its space science budget must shrink, and that the most effective way to explore the solar system is to send several inexpensive, small spacecraft to a planet rather than to send a single, large, complex spacecraft For example, the complex Viking orbiters and landers of 1976 would likely cost about $4 billion in 1996 dollars, whereas this year's Mars Global Survey orbiter and Mars Pathfinder lander and micro-rover combined must cost less than ten percent of that. Future U.S. orbiter and lander mission pairs must be even less expensive, costing no more than five percent of the Viking mission. Thus, to answer increasingly complex questions about Mars, ten agencies will need to combine their resources to build the sophisticated instruments necessary to acquire the data from the distant planet.

Mars has fascinated us from prehistoric times when humans first noticed that it and the other planets visible without telescopes appeared to wander against the background of the fixed stars. Circling the sun half again more distant than Earth, Mars has some similarities to Earth and some striking differences. A day on Mars is 24.6 hours, and it rotates on its axis inclined at an angle of 25 degrees to the plane of its orbit around the sun, quite close to Earth's 23.5 degree tilt. Thus, just like Earth, Mars has seasons over its 687 Earth-day year, and north and south polar caps made of water ice and frozen carbon dioxide that grow and shrink with the seasons. But because of its smaller size (half Earth's diameter and only ten percent of Earth's mass), its lower density, and its lower gravity (only a third of Earth's), Mars has a surface atmospheric pressure less than one percent of Earth's and it has lost most of its lighter gases, so that its atmosphere is composed mostly of heavier carbon dioxide. Because of its greater distance from the sun, Mars' average surface temperature is much lower than our own: almost ten degrees below zero Fahrenheit. But Mars' surface pressure and temperature must once have been much higher than they arc now, since photos taken from orbiting spacecraft clearly show eroded canyons and channels that were most likely carved by large volumes of flowing water. Although it is smaller than Earth, Mars has topographic feature that would dwarf those on Earth. Its largest volcano is 16 mile high and 350 miles in diameter-amparcd to Mt. Everest's and Mauna Kea's five mile heights. Mars' large equatorial canyon, Valles Marineris, is some 2500 miles long and three miles deep, compared to the Grand Canyon's 200 mile length and one mile depth.

Since 1962 and the flight of the Soviet Union's Mars 2 spacecraft, sixteen Amicrican and Soviet flyby, orbiting or landing spacecaft have visited Mars. Mariner 4 sent the first photos from another planet in 1965 when it found that the cratered surface of Mars looked similar to that of Earth's moon. Mariner 9 was the first spacecaft to orbit Mars, in 1971, and discovered its large volcanos, the canyon Valles Marineris, and its water-eroded canyons. The Viking orbiters and landers of 1976 confirmed the Mariner 9 discoveries in greater detail and did not find any evidence of life at the two landing sites, since billions of years of ult raviolet radiation from the sun have sterilized Mars' surface and prevented or ended any life that might have arisen.

Although these earlier missions have made striking and historical discoveries about Mars, they have raised almost as many questions, which the new international program of smaller, more frequent missions will try to answer. What happened to the water on this most Earth-like of planets, with its life-sustaining temperatures, after it dug the canyons? Does Mars provide an example of life arising elsewhere in the universe besides Earth? Can wc learn anything from Mars' history about how Earth could evolve in the face of continued human carbon dioxide production? To answer these questions, the International Mars ExplorationWorking Group proposes that orbiters, landers, balloons and rovers be launched every 25 months when Mars and Earth arc in positions to permit launches requiring the least energy.

- 1996: The U.S. will launch the Mars Pathfinder lander and micro-rover and the Mars Global Surveyor orbiter, which will also provide a communications relay platform for a Russian orbiter and small Russian landers with soil penetrators.

- 1998: The U.S. will provide the Mars Surveyor 98 orbiter and lander. France will launch a rover plus a balloon that will bounce through Mars' atmosphere, and Japan will send an orbiter.

- _200fl: Again, the U.S. will send an orbiter (which will also serve as a radio relay satellite), a lander and a rover, but wc will usc a Russian Molina launch rocket, and the U.S. spacecraft will be stacked on the rocket with a Russian spacecraft, Russia would like to include a long-range balloon to move through Mars' thin at mosphere and a Marsokhod surface rover, but they would need to be carried by a U.S. spacecraft.

•2003: This year would see the beginning of the International Mars Network Mission. The European Space Agency would provide an Italian orbiting communication satellite and four landers. The U.S. would send landers and rovers, and Russia would provide landers with soil penetrators.

•2005: The U. S. is planning orbiter and lander missions.

The United States portion of the 1996 missions (the Mars Global Surveyor orbiter which will launch in November, and the Mars Pathfinder lander and micro-rover which will launch in December) must cost less than $400 million combined. Future mission pairs at every launch opportunity--roughly every two years--must cost less than $200 million combined. The entire U. S. Mars Surveyor program must be carried out at less than $150 million per year. To reduce costs to these limits, JPL has chosen the same contractor to build the orbiter as it used for the 1992 Mars Observer mission: Lockheed Martin of Denver. The size of the spacecraft has been reduced from 2200 pounds to 1500 pounds, and, by using Mar's thin atmosphere to help drag the spacecraft into an orbit around the planet, the propellant needed to slow the spacecraft down so that it can be captured by Mars' gravity has been reduced from over 3000 pounds to less than 900 pounds. This means that Mars Global Surveyor can be launched on a smaller Delta II rocket instead of the much larger--and more expensive--Titan 111 rocket required for Mars Observer. An international group of over 100 scientists has provided experiments similar to about half of those carried on Mars Observer (the remainder will be carried by the 1998 Surveyor). A camera able to see features as small as five feet across will be able to study landforms over the entire planet, because, when the orbiter reaches its final mapping orbit in January 1998, that orbit will pass over Mars' poles and cross Mars' equator at 2:00 p.m. (Mars local time) every time it's on the planet's sunny side so that viewing conditions for the camera are the best possible. A laser altimeter will be able to provide a topographic map for Mars with an accuracy of six feet. The distribution of minerals over the planet's surface will be determined by an instrument that measures from space the infrared (heat) energy emitted by the surface over many wavelengths. A magnetometer will determine whether Mars has a magnetic field like Earth does; so far, none has been detected. Finally, using Mars Global Surveyor's radio signal, scientists can study the structure of its atmosphere, its shape, surface topography and the bumpiness of its gravity.

A month after Mars Global Surveyor's launch, in December of this year, JPL and NASA will launch Mars Pathfinder: a lander containing a micro-rover with a total launch weight of almost a ton (including propellant). Pathfinder is really a demonstration of several technologies as well as having the capability to get significant science on Mars' surface. As it approaches Mars to land on July fourth 1997, Pathfinder will be slowed, not by a rocket, but by Mars' thin atmosphere, with the lander and rover protected from the white-hot heat and shock by an aeroshell. Then a parachute opens, small retrorockets slow its descent, large airbags cushion its landing, and three petals open to orient it upright. All of these entry, descent and landing operations are an engineering experiment. Other technology experiments include its electronic integrated circuit chips which control Pathfinder and process its science data, its commercial computer (rather than a special computer built for space), and its gallium arsenide-germanium solar power system. Pathfinder's micro-rover is about a foot high by two feet long by a foot-and-a-half wide, and weighs 35 pounds. It carries two cameras, one pointing to the front and one toward the rear. The lander's scientific instruments include a spectrometer to measure several energies of atomic particles (protons and helium nuclei) and X-rays to study the elements comprising Mars' surface. It also has a stereo multicolor imager to get pictures from the surface of Mars, and a weather station to measure the daily pressure, temperature and density of Mars' atmosphere. Because it is an engineering experiment, Pathfinder's design life is quite short: one month for the lander and a week for the rover.

The next decade should see a ncw burst of Mars exploration, similar to the major advances that were rnadc during the 1970s. This time, however, it should be an international effort, and all the spacecraft are designed to be much more cost-effective than their ancestors. Mars Global Surveyor and Pathfinder will be the first planetary spacecraft of NASA's ncw era of shorter missions, smaller spacecraft, and limited focussed science objectives.